

## Description

Optoelectronic module and method for the production thereof

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The invention relates to an optoelectronic module in accordance with the preamble of patent claim 1 and to a method for producing an optoelectronic module in accordance with the preamble of patent claim 10.

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This patent application claims the priority of German patent application 10361650.0, the disclosure content of which is hereby incorporated by reference.

15 In many applications with semiconductor components for emitting or detecting electromagnetic radiation, additional optical devices are used for shaping said electromagnetic radiation. Significant losses of radiation intensity often occur in this case on account  
20 of reflections between the semiconductor component and the optical device. This relates in particular to reflections at interfaces between the semiconductor component and the optical device.

25 In order to avoid such reflections to the greatest possible extent, it is important for the optical device to be optically connected as well as possible to the semiconductor component, for which purpose it is necessary to avoid in particular large jumps in  
30 refractive index along the beam path. It is known to use gels having a correspondingly adapted refractive index for this purpose, said gels filling interspaces between the semiconductor component and the optical device along the beam path.

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One disadvantage when using such gels is that a special manufacturing technology using a special metering installation is necessary for the application of a gel,

which causes a significant additional technical effort. Moreover, gels can easily be deformed irreversibly and are thus suitable only to a limited extent for many non-static applications wherein mechanical strain on  
5 the component such as vibrations may occur.

One aim of the present invention is to provide an optoelectronic module of the type mentioned above which has an improved optical connection between the  
10 semiconductor component and the optical device. Furthermore, an intention is to specify a simple and cost-effective method for producing such an optoelectronic module.

15 These objects are achieved by means of an optoelectronic module in accordance with claim 1 and by means of a method in accordance with claim 10, respectively. The dependent claims relate to preferred developments and advantageous configurations of the  
20 invention.

According to the invention, an optoelectronic module of the type mentioned at the beginning has a connecting layer made of a radiation-transmissive, deformable  
25 material being arranged between the radiation coupling area and the optical device. The optical device and the semiconductor component are fixed relative to one another in such a way that they are pressed against one another and that the connecting layer is thereby  
30 squeezed in such a way that it generates a force that strives to press the optical device and the radiation coupling area apart.

A "radiation coupling area" is to be understood as a  
35 radiation out-coupling area and/or a radiation in-coupling area, i.e. an area of the semiconductor component via which radiation is coupled out from the

semiconductor component or coupled into the semiconductor component.

5 In the context of the invention, "pressed against one another" means that the optical device and the semiconductor component are held permanently in a state pressed against one another, counter to the force of the connecting layer, by a fixing device, as a result of which a deforming force acts on the connecting  
10 layer.

The force of the connecting layer counteracts the deforming force. When the deforming force is removed, i.e. when the relative fixing between optical device  
15 and semiconductor component is removed, the force of the connecting layer has the effect that the optical device and the semiconductor component are pressed apart.

20 The connecting layer is configured in such a way that the force that it generates prevents to the greatest possible extent any formation of air gaps between the connecting layer and the adjoining interfaces. This applies in particular to an entire operating  
25 temperature range of the module and to any action of additional deforming forces on the connecting layer, such as, for instance, vibrations or centrifugal forces.

30 Accordingly the connecting layer comprises in particular material which has a higher strength than a conventional gel and which is not flowable over the entire operating temperature range of the optoelectronic module.

35 The invention can effectively compensate for fluctuations in a distance between the semiconductor component and the optical device which may occur for

example in the event of temperature fluctuations in combination with materials of the semiconductor component and the optical device having different expansion coefficients. If the distance increases, for instance, the compressed connecting layer expands and thus minimizes the risk of an air gap forming between the semiconductor component and the radiation coupling area.

10 The optical device has the purpose of at least partly deflecting electromagnetic radiation that is emitted or received by the semiconductor component. It may be, for instance, a lens for compressing or expanding a cone of the electromagnetic radiation, or a prism, by way of  
15 example.

In one advantageous embodiment of the optoelectronic module, the connecting layer has a minimum thickness of 30  $\mu\text{m}$ , preferably of 100  $\mu\text{m}$ . The connecting layer  
20 particularly preferably has a thickness of greater than or equal to 150  $\mu\text{m}$  and less than or equal to 350  $\mu\text{m}$ . Such a thickness is advantageous in order that the semiconductor component and the optical device can be pressed against the connecting layer in such a way that  
25 no air gap remains between them and the connecting layer generates a force that is strong enough that distance fluctuations and expansion differences can be compensated for in the best possible manner.

30 The connecting layer preferably has a lacquer, particularly preferably a circuit board lacquer, in which case a "circuit board lacquer" is to be understood as a lacquer which is suitable as a protective lacquer for printed circuit boards. In  
35 contrast to a use of a gel, the use of a suitable circuit board lacquer makes it possible to have recourse to the standard lacquering process, as a

result of which the manufacturing effort and also the manufacturing costs can be significantly reduced.

5 In a further advantageous embodiment, a surface of the carrier element is at least partly coated for protection against external influences with a material that is also contained in the connecting layer. A suitable circuit board lacquer may expediently be used for this, that is to say that the circuit board lacquer  
10 is applied both on a surface of the carrier element and between the semiconductor component and the optical device. Costs can be saved as a result since two functions are fulfilled by one material layer.

15 In a particularly expedient embodiment of the module, a refractive index of the connecting layer is adapted to a refractive index of a material of the semiconductor component that adjoins the connecting layer and/or to a refractive index of a material of the optical device  
20 that adjoins the connecting layer.

The optical device advantageously has refractive and/or reflective elements.

25 The semiconductor component is particularly preferably a luminescence diode component. In one advantageous embodiment, the component is a surface-mountable semiconductor component.

30 In a method of the type mentioned at the beginning, according to the invention, prior to mounting the optical device, a curable and - in the cured state - radiation-transmissive and deformable composition is applied at least over the radiation coupling area of  
35 the semiconductor component. Afterward, the applied composition is at least partly cured or let to be cured. In a further method step, the optical device and the semiconductor component are fixed relative to one

another in such a way that they are pressed against one another and the composition is thereby squeezed in such a way that it generates a force that strives to press the optical device and the radiation coupling area  
5 apart.

With regard to the expression "pressed against one another", the explanation stated above in connection with the optoelectronic module holds true in connection  
10 with the method as well. The same applies to the subject matter of the deformable composition.

The composition is expediently applied in the form of a layer having a minimum thickness of 30  $\mu\text{m}$ , preferably  
15 of 100  $\mu\text{m}$ . The composition is particularly preferably applied in the form of a layer having a thickness of greater than or equal to 150  $\mu\text{m}$  and less than or equal to 350  $\mu\text{m}$ .

20 The composition preferably has a lacquer, particularly preferably a circuit board lacquer, which is deformable, for example elastically deformable to the greatest possible extent, in a cured state. As already mentioned above, a lacquer, in particular a circuit  
25 board lacquer, can be applied significantly more cost-effectively and with a significantly lower effort than a gel, for instance.

In a particularly expedient embodiment of the method,  
30 the composition is applied at least to part of a surface of the carrier element for protection against external influences. This can be realized particularly expediently with a lacquer, in particular with a circuit board lacquer.

35 In a particularly advantageous manner, the composition is applied to the radiation coupling area and to the surface of the carrier element in a single method step.

Further features, advantages and expediencies of the invention emerge from the exemplary embodiments described below in connection with Figures 1 and 2, in  
5 which:

Figure 1 shows a part of a schematic sectional view of an optoelectronic module at one method stage of an exemplary embodiment of the method, and  
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Figure 2 shows a part of a schematic sectional view of an exemplary embodiment of the optoelectronic module.

Identical or identically acting constituent parts are provided with the same reference symbols in the exemplary embodiments and figures, respectively. The elements illustrated in the figures are not to be regarded as true to scale, but rather may be illustrated in part with an exaggerated size in order  
15  
20 to afford a better understanding.

The part of the optoelectronic module illustrated in Figure 1 has a carrier element 1, on which a semiconductor component 2 is applied. The carrier element comprises electrical connection electrodes 41, 42, to which the semiconductor component 2 is electrically conductively connected by housing connection lines 17, 18, respectively, by means of a solder 15.  
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30 The semiconductor component is a light-emitting component, by way of example. It has a housing basic body 11, to which a light-emitting diode chip 10 is mounted in such a way that its electrical connection  
35 sides are electrically conductively connected to the housing connection lines 17, 18. By way of example, a rear side of the light-emitting diode chip 10 is soldered onto a first housing connection line 17 and a

front side is electrically conductively connected to a second housing connection line 18 by means of a bonding wire 13. The light-emitting diode chip 10 is encapsulated with a casting compound 14, whose outer  
5 surface remote from the housing forms a radiation coupling area 16, via which light generated during the operation of the semiconductor component 2 is coupled out from the latter.

10 As an alternative, the semiconductor component 2 may for example also be a detector for electromagnetic radiation. In this case, electromagnetic radiation that is incident on the semiconductor component 2 is correspondingly coupled into the semiconductor  
15 component 2 at the radiation coupling area 16.

Semiconductor components of this type are generally known to a person skilled in the art and are therefore not described any further here.

20 The optoelectronic module may have only one or else a plurality of such semiconductor components 2 for emitting or detecting electromagnetic radiation. In addition, further components of different type such as,  
25 for instance, resistors, capacitors and/or inductances may also be applied on the carrier element 1 and/or be electrically conductively connected thereto.

A radiation-transmissive, deformable composition in the  
30 form of a layer is applied both on parts of the surface of the carrier element 1 and on the radiation coupling area 16 of the semiconductor component 2.

On the surface of the carrier, said layer serves as a  
35 protective layer 7 and may in this case also be applied to possibly present components of different type which have already been mentioned above. It protects the surface of the carrier and, if appropriate, the

components of different type against external influences.

On the surface of the semiconductor component 2, the  
5 layer serves as a connecting layer 6, by means of which  
the semiconductor component and an optical device 3  
arranged above the radiation coupling area 16 (see  
Figure 2) can be optically connected to one another.

10 The protective layer 7 and the connecting layer 6 are  
for example made of an identical material, for example  
a suitable circuit board lacquer, and are for example  
both applied in a single method step. As a result, for  
instance by means of a standard process of circuit  
15 board lacquering, not only the protective layer 7 but  
also simultaneously the connecting layer 6 are  
advantageously produced without significant additional  
effort.

20 A suitable circuit board lacquer is radiation-  
transmissive, deformable in a cured state and can,  
moreover, preferably be applied in a sufficiently thick  
layer in order that the optical element 3 can be  
pressed against the connecting layer 6 in such a way  
25 that the connecting layer is deformed and that there is  
no air gap between the optical element 3 and the  
connecting layer.

The connecting layer has for example a thickness of  
30 300  $\mu\text{m}$  and comprises for example a silicone lacquer.  
The thick-film lacquer DSL 1706 FLZ from Lackwerke  
Peters GmbH & Co KG, for instance, is suitable for this  
purpose. It is based on polyorganosiloxane and has fast  
condensation crosslinking at room temperature.

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For a good optical connection of the semiconductor  
component 2 and the optical device 3, the refractive  
index of the material of the connecting layer 6 is

adapted to the greatest possible extent to the refractive indices of the casting compound 14 and the optical device 3, i.e. it is approximately equal to them, or, if the refractive indices of the casting compound 14 and the optical device 3 differ significantly from one another, the refractive index of the material of the connecting layer 6 lies between them.

After the connecting layer 6 has cured, an optical device 3 is mounted above the radiation coupling area 16 of the semiconductor component 2 in such a way that the connecting layer 6 is squeezed. For this purpose, the carrier element 1 has for example two or more mounting bars 8 having a thread which project perpendicular to a main plane of extent of the carrier element 1.

The optical device 3 is for example an optical convex lens having lateral extensions into which holes are introduced. The optical device is mounted in such a way that the mounting bars 8 are passed through the holes. The optical device is subsequently fixed by means of nuts 9, so that it is pressed against the connecting layer, which is indicated by arrows at the optical device in Figure 2. The connecting layer is thereby compressed or squeezed together. In the deformed state, the connecting layer 6 is, moreover, pressed apart somewhat in its main plane of extent (compare Figure 1 with Figure 2).

The optical device may have refractive and/or reflective elements as an alternative to the lens illustrated in Figure 2.

Moreover, it is possible also to apply the connecting layer to the side 20 of the optical device 3 facing the semiconductor component and to mount the optical device

together with the connecting layer 6 over the radiation coupling area 16. However, it is preferred firstly to apply the connecting layer 6 over the radiation coupling area 16 and afterwards to mount the optical device 3 over the connecting layer 6.

There may additionally be further elements arranged between the connecting layer 6 and the radiation coupling area 16 or the optical device 3, i.e. the connecting layer needs not necessarily be directly adjacent to the radiation coupling area 16 or the optical device 3.

The scope of protection of the invention is not restricted by the description of the invention on the basis of the exemplary embodiments. Rather, the invention encompasses any new feature and also any combination of features, which in particular comprises any combination of features in the patent claims, even if this combination is not explicitly specified in the patent claims.